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Impact of SDN and NFV on OSS/BSS

ONF Solution Brief

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Open Networking Foundation
2275 E. Bayshore Road, Suite 103, Palo Alto, CA 94303
www.opennetworking.org

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1 Introduction

There are few topics as timely and under-represented as the impact of Software Defined Networking (SDN) and NFV (Network Function Virtualization) on existing Operations Support Systems (OSS) and Business Support Systems (BSS) solutions. Integration of new SDN and NFV architectures, with existing customer OSS/BSS, is a pain point to the extent that deployments are being delayed due to end-user concerns about the effort and risks involved.

In addition to the challenge of integrating IT systems, there is the need to adapt business processes and operations team skill sets to realize the full benefits of the new virtualized infrastructure, which offers the potential for automated operations work streams.

The objective of this Solution Brief is to help end-users understand the impact that SDN and NFV have to existing systems and to understand the migration paths to the next generation systems and processes. The scope of this document includes OSS/BSS for OpenFlow™ switching infrastructures as part of NFV reference architecture and associated WAN interconnect.

For more information on SDN and the work of the Open Networking Foundation (ONF) please see the white paper 'Software-Defined Networking: The New Norm for Networks'.

https://www.opennetworking.org/images/stories/downloads/sdn-resources/solution-briefs/sb-sdn-migration-use-cases.pdf

2 Executive Summary

The Operator OSS/BSS environment provides essential business functions and applications such as operations support and billing. OSS/BSS is a key enabler for existing and future business.

SDN and NFV are transforming traditional networks into software programmable domains running on simplified, lower cost hardware, driving the convergence of IT and Telecoms. This convergence will revamp network operations, enable new services and business models, and impact existing OSS/BSS.

The carrier vision for SDN/NFV is characterized by a number of tangible benefits. Services will be orchestrated in a dynamic and agile way, and distributed across a shared underlying infrastructure. SDN control offers programmability, agility and openness in the network infrastructure that underpins the NFV virtualization infrastructure (NFVI) and datacenter interconnects.

The virtualized infrastructure enables operators to efficiently trial new service concepts, rapidly launch and monetize the offerings, and discard with minimal wasted investment offerings that do not achieve expectations (i.e. 'fail fast').

SDN and NFV will streamline data collection, analysis and business decision-making processes, and in turn automate network operations, charging and billing to offload and simplify OSS/BSS systems, which will continue to collect customer, network, service and other important data.

OSS/BSS may be overhauled to become cloud-based, integrating with legacy systems and able to operate in any virtual environment. At the top of the architecture hierarchy are BSS systems, which will set policies based on subscriptions and manage reporting and billing. At the bottom are control and management of the VNFs and NFVI, which is an integral function of SDN.

The ETSI NFV ISG envisions diverse, multi-vendor services addressing a broad range of use cases. There will be a new division of responsibility between the OSS and the SDN Controller as indicated in the NFV architectural framework. In the new paradigm, the OSS will address static, or slow moving, service attributes, while the new Orchestration and SDN Controller addresses dynamic configuration and real-time network state transition. The OSS and BSS will retain their overarching role.

Figure 1 broadly illustrates the new paradigm. A key difference, in these architectures, is the different response time frames. Network Management Systems (NMS) configures Network Elements (NEs) statically, at relatively slow response times, whereas the SDN controller will operate in real-time.

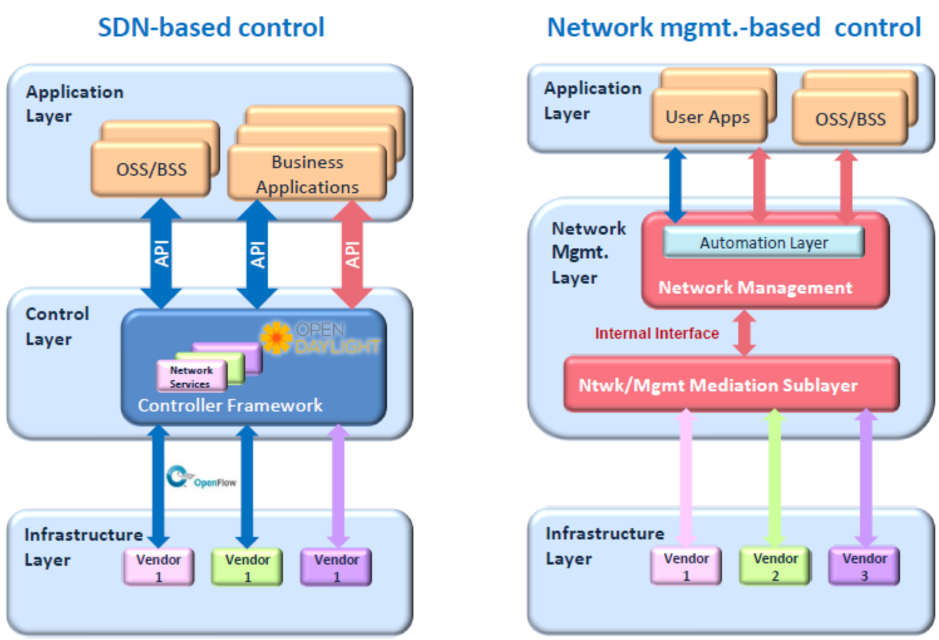


Figure 1: New Paradigm vs Legacy

To leverage these benefits, OSS/BSS systems must be consolidated and modernized. This solution brief discusses the transformation of legacy OSS/BSS Architectures based on new requirements in an SDN/NFV world.

3 Market Trends& Business Drivers

Telecom business models and network architectures have remained relatively stable over the years. However, proliferation of mobile devices and uptake of data services, the increasing competition from over-the-top (OTT) providers, dramatic growth in demand for bandwidth (driven primarily by video), and ever-present pressure to cut costs and improve efficiency, have motivated service providers to transform their networks and operations. SDN and NFV are expected to be important factors in this transformation.

Cloud technologies, catalyzed by SDN and NFV, will reduce costs and introduce new revenue streams. 64% of CMOs and CTOs/CIOs are working to incorporate cloud-based technology into their OSS/BSS systems this year and 58% of them believe their OSS/BSS systems need to be modernized and consolidated. Existing OSS/BSS architectures will not meet the demands and challenges of emerging virtualized environments.

4 Challenges & Barriers to Success

SDN and NFV will not achieve their potential value until OSS and BSS systems are aligned with the new technologies. A service can be turned up or torn down quickly but until provisioning, configuration, billing and fault management are automated, dynamic, and intelligent, SDN and NFV cannot be fully leveraged.

The ability to integrate and interact is not the only challenge facing back office systems. SDN and NFV are poised to reduce the cost of capacity and in turn improve service density. The knock-on effect will be an increase in service management overhead, which will create a greater workload for OSS/BSS.

OSS and BSS systems will need to adapt to avoid becoming a bottleneck. For instance, billing systems will need to support more billing events as service instances grow significantly. Multiple customers' traffic must be efficiently aggregated, with unique subscriber profiles, many application types, and distinct policies.

The NFV infrastructure must dynamically reallocate its resources between different virtual network functions to meet variations in traffic composition. Current OSS systems cannot support this level of real-time dynamics and policy driven real-time service variation because:

Static Service configuration: In current OSS systems, the network is assumed to be statically configured. The underlying assumption is that services change infrequently.

Service Parameters are rigidly fixed: Not only is the service type fixed, but service parameters are either fixed by the OSS to static values or not selectable.

No policy driven real-time service variation: OSS systems do not allow customer-driven or application driven real-time variation. Changing any aspect of the service is complex and time consuming.

No ability to respond at packet/flow timeframe: OSS systems are designed for services with typical subscription periods of months or years, and only in special cases weeks or days. State-of-the-art cloud services may be offered for hourly timeframes, but OSS and BSS systems do not usually achieve such fine granularity.

In SDN and NFV, the network is no longer static. The SDN controller enforces application and/or subscriber policies by dynamically optimizing network resource utilization, service placement, etc.

OSS systems for SDN and NFV must accommodate dynamic network changes and provide the freedom for SDN Controllers and NFV Orchestrators to dynamically apply policy-driven changes in response to application or traffic demands, while maintaining full FCAPS support.

5 Legacy OSS/BSS architectures

Today's OSS/BSS architectures are built on a solid but aging foundation, developed over several decades, for telecom services that were relatively static and predictable. OSS/BSS systems are undergoing significant changes in order to benefit from, and keep up with, the pace of innovation ushered in by SDN and NFV. Operators seeking to take advantage of SDN/NFV to optimize their networks and improve agility can only do so when a new generation of OSS/BSS processes is enhanced to cope with this new virtualized world. Migration will take time, as operators must adapt complex and proprietary legacy systems.

OSS/BSS systems have not been totally static over the years. Significant technology shifts have motivated change, including migration from analog to digital systems, circuit to packet-based services, the breakup of the Bell system and the growth of the internet. In each instance, OSS/BSS systems were adapted to those new realities. Frequent acquisitions and spinoffs resulted in the need to upgrade OSS and BSS systems as well, not without complexity, time, and cost.

TM Forum categorizes key business functions as part of its Business Process Framework (BPF):

- Strategy, Infrastructure and Product – covering planning and product lifecycle management
- Operations – covering the core of operational management
- Enterprise management – covering corporate or business support management

OSS/BSS systems must continue to address all three of these functions in the SDN era. The BPF defines a comprehensive taxonomy including fulfillment, assurance, billing and product life-cycle management. Most operators will further break these down into specific functions that match their need for managing customers, systems, suppliers, etc.

OSS/BSS systems have traditionally crafted, often over years of experiential learning, into highly customized platforms. For example, current strategy, infrastructure and product functions include tools to plan and build business cases for new service offerings. These tools can range from highly integrated and automated systems taking a myriad of variables into account, to the ubiquitous spreadsheet exercise maintained manually.

While the BPF provides a comprehensive and holistic view, OSS/BSS functions are classified as order management, service provisioning, service assurance or billing. These are often business-critical and supported by internally developed or vendor-acquired tools, tailored to each operator's businesses and services.

6 OSS/BSS Requirements in an SDN / NFV world

To address the dynamic, flow-based SDN architecture, OSS/BSS must provide:

Support for dynamic real-time OSS: The OSS must allow for real-time network and service changes in response to traffic content or network events. The granularity of real-time responsiveness should be at the flow level, i.e. sub-second. If the OSS cannot provide real-time responsiveness, then it must enable the SDN controller to do so.

Separation of Network Configuration and management of Network State: In a traditional network, the OSS will configure the network to the desired service parameters, corresponds directly to long-term network state. In SDN/NFV, service parameters must constantly change in real-time, in response to traffic variations (e.g. different application flows). The OSS should configure the network infrastructure (e.g. the OpenFlow switch with OF-Config) but allow the SDN Controller the freedom to vary the specific network state or service parameters in real-time on a flow by flow basis (e.g. adjust the flow tables or service chains).

Support for a modeling approach to network services: The OSS should support service modeling to automate mapping to devices, vs. static adapters or rigidly specified service parameters.

Interworking with network orchestration platform: The OSS will configure the NFVI, but the NFV orchestrator will configure the actual virtual network functions (VNFs) running on this infrastructure and the allocation of resources to VNFs. The OSS and NFV orchestrator must be able to interwork and refer to a common policy platform and management information model.

Interworking with SDN controllers: The OSS will configure the SDN Infrastructure, e.g. OpenFlow switches, and SDN Controller and environment. The SDN controller will apply network services and business application policies to the SDN network, e.g. via continually updating and maintaining OpenFlow flow tables. The OSS and SDN controller must be able to interwork and refer to a common policy platform and management information model.

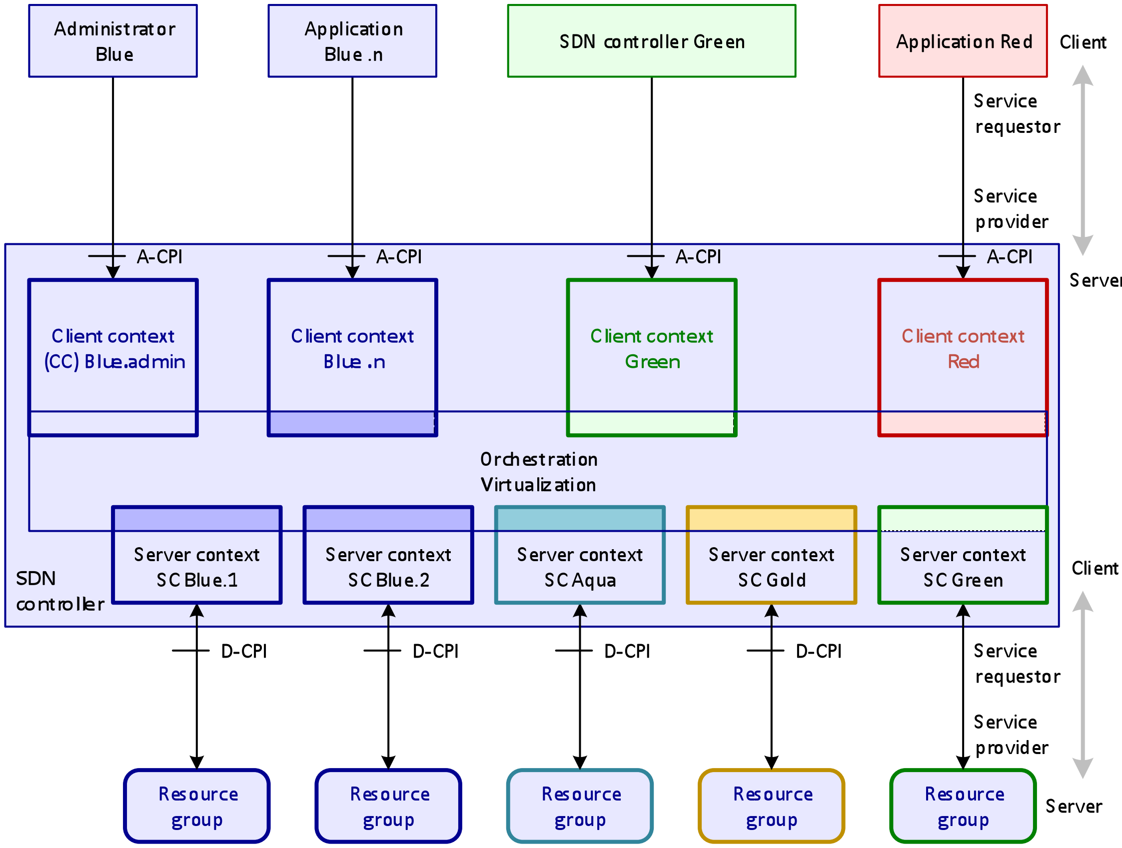
7 Components of an OSS/BSS reference architecture

The OSS/BSS reference architecture should (as depicted in Figure 2):

- Support dynamic real-time SDN control through a combination of OSS and network orchestration
- Separate static Network Configuration tasks (managed by the OSS) and the dynamic real-time management of Network State (managed by SDN controllers)
- Support flexible service modeling (instead of static OSS adapters), e.g. adopt IETF Yang (RFC 6020) modeling approach
- Support Interworking of the operator's OSS/BSS with the network orchestration platform
- Support Interworking of the operator's OSS/BSS with the network's SDN controllers

Figure 3, illustrates the high level SDN Architecture components (Application Plane, North-Bound-Interface A-CPI, Control Plane, South-Bound-Interface D-CPI, and the Data Plane) and the interworking with the OSS/Management components based on the ONF SDN Architecture framework:

Figure 3: SDN Architecture



The picture illustrates that Blue service is provided from a separate NBI, that the Blue controller controls five resource groups (e.g., network elements), two of which are owned by Blue, three of which are contracted from other entities Aqua, Gold and Green. As both an NBI client and a D-CPI server, Green and Blue have an east-west relationship in which either can request services from the other.

How much of this should be abstracted into a view from the OSS is for discussion, but it would be good not to lose all of it. In admin role, the OSS cares about everything here.

The OSS/Management provides policy-based configuration and management at each of the SDN layers: Application, Control Layer and Infrastructure Layer (data plane), which set the relatively static operational parameters within which the SDN controller and SDN applications are able to operate. At the same time, SDN applications and the SDN controller manage the real-time response of the network to traffic flows in accordance with policies enforced by the OSS.

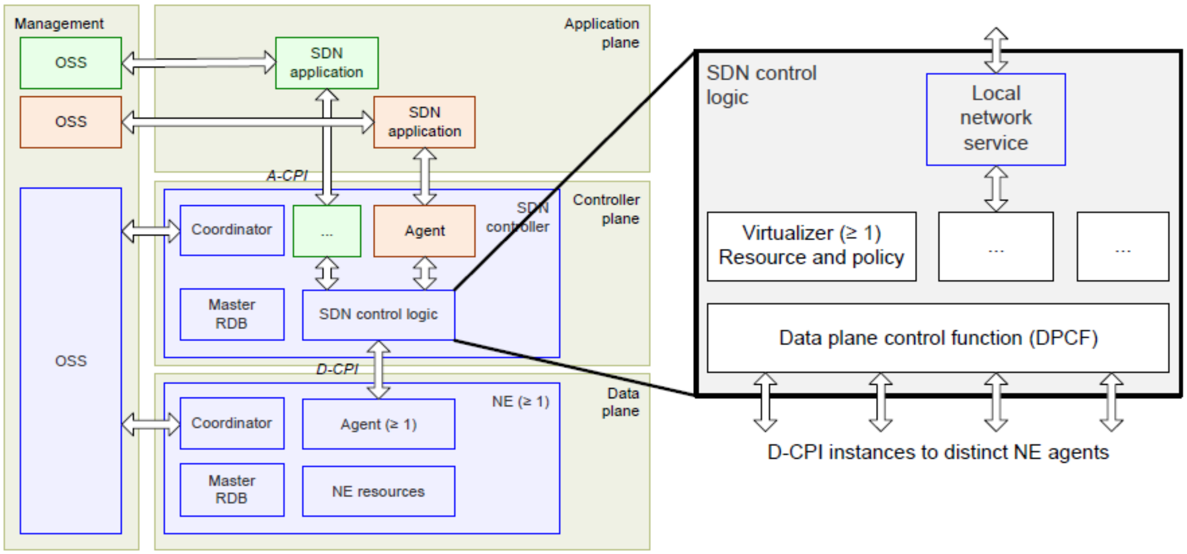


Figure 5: SDN Control Logic Detail

Figure 5 Illustrates that the OSS oversees dynamic application of real-time, policy-driven flow rules through SDN control logic, and coordinates between the OSS, SDN Controller, and SDN client and server contexts.

8 Integrating SDN/NFV with OSS/BSS

There will be a sharing of responsibility between the traditional OSS and the newly deployed SDN controllers and NFV orchestration. The OSS will manage the relatively static configuration parameters and limit overall resources assigned to sub-networks or services. The SDN controller and NFV orchestration platforms will then dynamically manage these network resources to apply policy-based services in real-time to individual traffic flows.

OSS systems, consistent with the ETSI NFV architectural framework, must support the Os-Ma interface between the traditional OSS/BSS and the NFV Management and Orchestration (MANO) framework as shown in Fig 4. OSS/BSS systems delegate fine-grained management of the NFV Infrastructure and the specific VNFs to the VIM and the VNF Manager, which in turn are orchestrated by the NFV Orchestrator (NFVO). Thus, the OSS/BSS will be responsible for the high level configuration of the infrastructure and network functions, but the NFV MANO framework will manage the dynamic aspects of infrastructure and services.

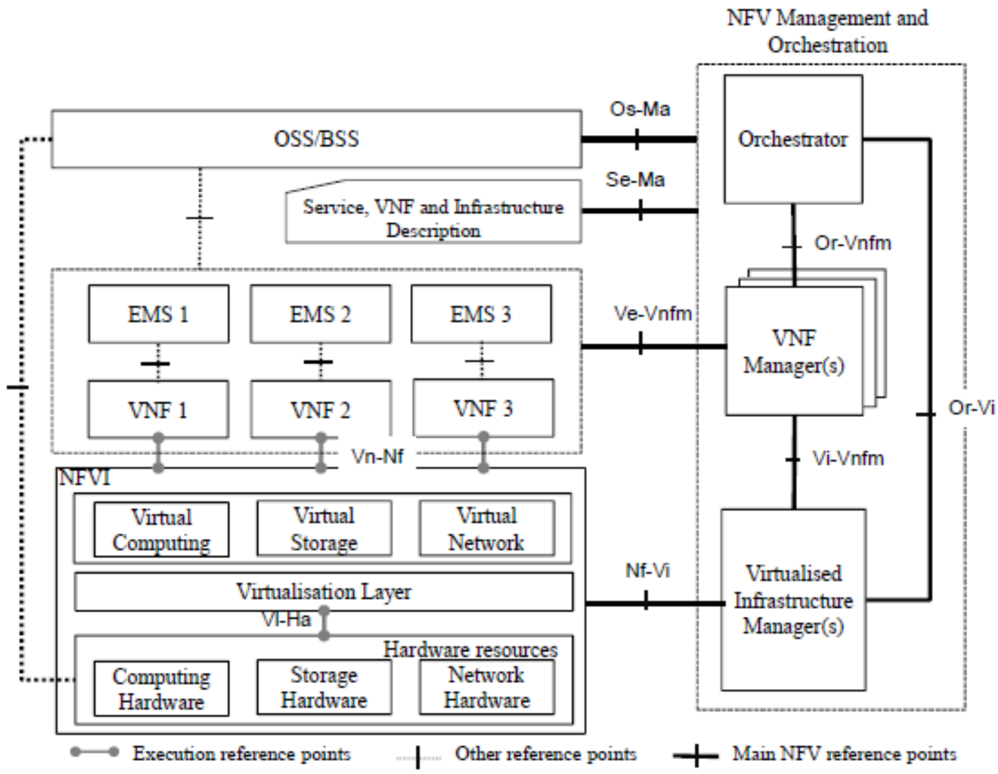


Figure 6: NFV Reference Architecture Framework

Source: ETSI NFV Architectural Framework (ETSI GS NFV 002)

The integration with the SDN Controller and applications will follow a similar approach. The OSS will manage the configuration of the SDN data plane, configure and set policies for the SDN controller and control SLAs for SDN Applications, but the dynamic control of the SDN Forwarding Plane will be managed by the SDN Controller and the SDN Control to Data-Path Interface (CDPI).

Figure 7 shows the key components of an SDN Architecture and its interworking with the OSS systems. The SDN Architecture consists of the Application Plane with various SDN Applications, the Control Plane with one or more SDN Controllers, and the Data Plane with the SDN Network Elements. The OSS/Management systems control and configure the SLA parameters for each SDN Application as specified in individual customer contracts. The OSS also configures policy and resource assignments and limits to the SDN Controller, and performs the SDN data path network element initial configuration, e.g. via OF-Config. The SDN Applications apply their application logic subject to the configured SLA parameters that are relevant to current data flows and then pass the high level application instructions to the SDN controller via the North-Bound-Interface (NBI). The NBI also passes current network state, statistics and events in real time back to the SDN Application.

The SDN Controller translates the high level application instructions into low-level instructions for the data path forwarding network elements utilizing the Southbound CDPI, e.g.OpenFlow. The Southbound CDPI also collects data path network element statistics, alarms and fault information, which is taken into account in the SDN Controller's logic and also conveyed at a higher level where required to the application layer and to the OSS system. The combination of Application layer, NBI, SDN Controller and Southbound CDPI handle the real-time explicit control of the data path elements in line with the policy and resource limits configured by the OSS/Management systems.

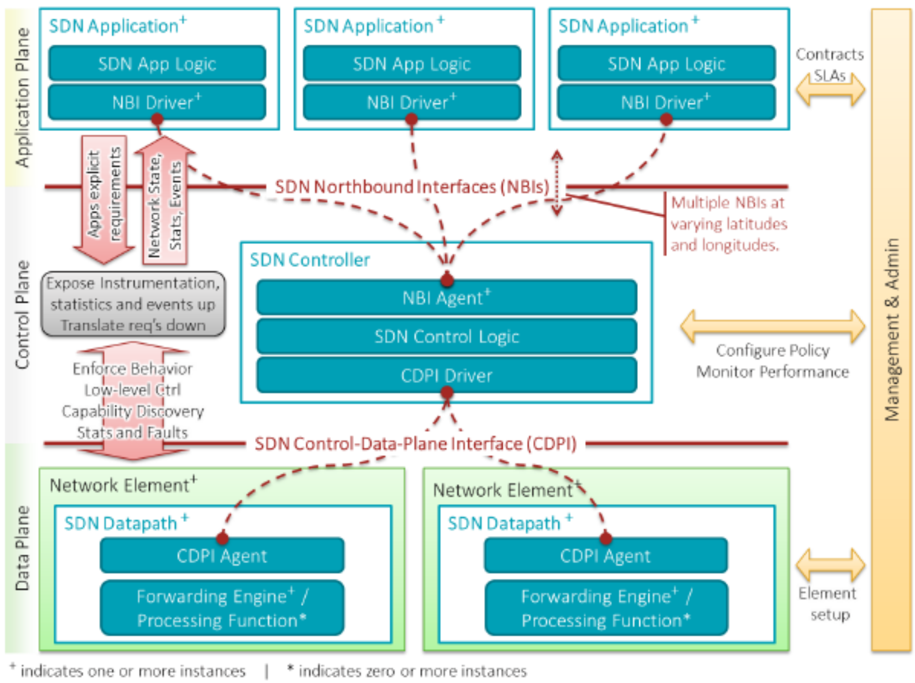


Figure 7: Key Components of an SDN Architecture and Interworking with OSS

Source: ONF SDN Architecture Overview, Dec 2013

In regard to Data Center or Cloud based services, some of the real-time network control will be exerted directly by the DC/Cloud Orchestration platform, e.g.Openstack through its Neutron plug-in. This will apply real-time network changes consistent with compute and storage resource allocations and movements. The DC/Cloud OSS would configure the corresponding network elements and set resource limits. The Openstack Neutron plug-in will manage these resources in real-time to deliver services seamlessly across the compute, storage and networking layers of the DC/Cloud.

9 Migration strategies

Service Providers, and Enterprises, moving to deploy virtualized network architectures based on SDN and NFV, are likely to evolve the OSS/BSS systems in stages. Existing operators and enterprise networks have a significant installed base and it is unrealistic to replace all existing infrastructure. The evolution towards SDN and NFV is, therefore, likely to be as a set of islands in a sea of legacy networking capability. In some sense, this will mirror the deployment of IPv6 islands in a large established ocean of IPv4 networks. The new capability will be deployed first where it brings the most value or where the legacy network requires upgrades anyway.

As the new networking capability is deployed, the OSS/BSS systems must evolve in parallel, otherwise the benefits of the new SDN or NFV networks cannot be fully realized, as described in earlier sections.

Figure 9 depicts a typical network of today, where the network functions are based on physical hardware (PNF) and are controlled by their individual EMS through the OSS/BSS layers, and network connectivity is provided by a static EMS provisioned WAN network.

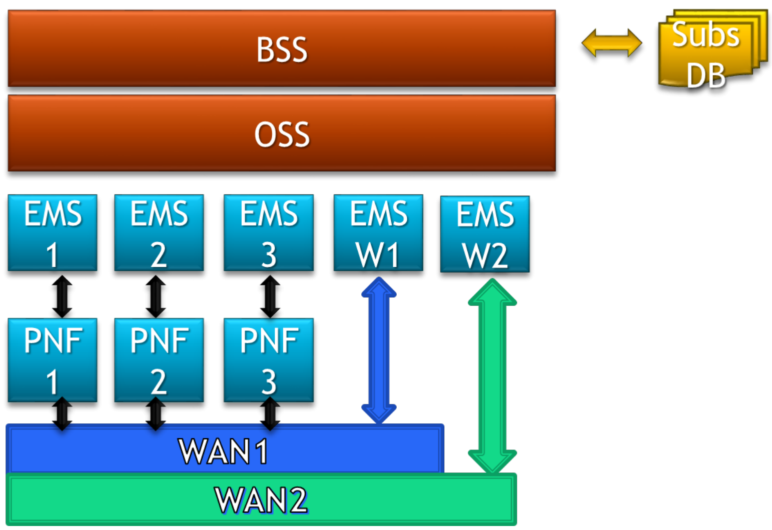


Figure 9: Legacy Physical Network Functions with EMS

Figure 11 shows the Long Term Vision where the network functions are all virtualized and orchestrated by an NFV Orchestration platform. The network connectivity will be partially provided by an SDN network controller integrated in the NFV Infrastructure, and partly by an SDN based physical network (e.g. WAN connectivity).

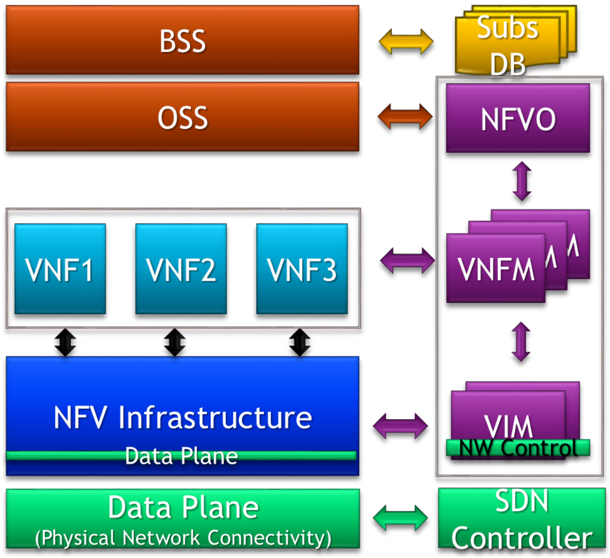


Figure 11: Long Term Vision

The transition from the current network to the longer term vision can be made step-by-step, e.g. on the basis of a set of geographic or functional network islands, or sub-domains, or simply function by function. Figure 13 depicts such a migration scenario where the network is built upon legacy, and statically provisioned, WAN connectivity with EMS-controlled physical network functions, and built upon on a virtualized NFV infrastructure with underlying SDN connectivity, all orchestrated by SDN controllers and NFV orchestration platforms in close cooperation with the evolved OSS/BSS platform.

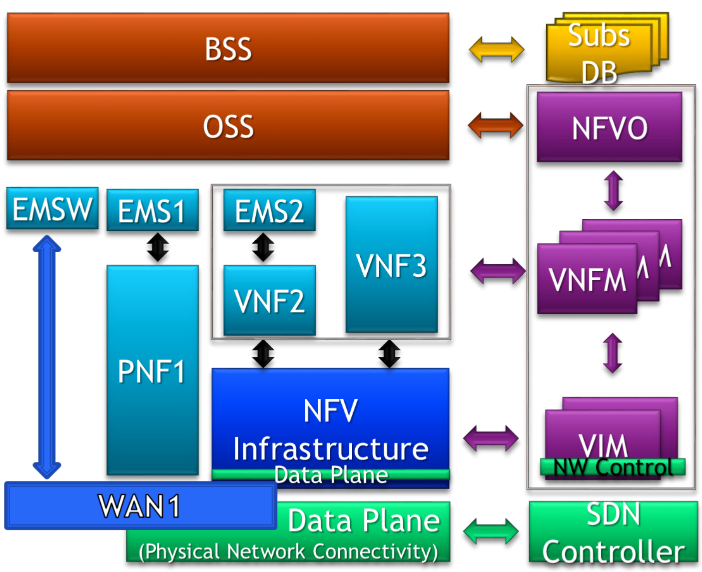


Figure 13: Migration Scenario

The ETSI NFV ISG anticipates that, in the long term, the VNF will be fully managed by the corresponding VNF managers, but, in the interim, there will still be a (possibly reduced) EMS manager attached to each VNF that will assist the VNFM in the management of the VNF. Figure 13 shows a progression from WAN connectivity to SDN network and from EMS managed physical network functions to orchestrated VNF. This transition can be done domain by domain or service by service.

Previously the OSS managed the network state in a static manner, configuring the network to operate against pre-defined policy, which was not intended to change. With the introduction of SDN, the OSS will set policy constraints, but does not need to be aware of dynamic real-time state transitions, which will be managed by the SDN Controller. The installed legacy OSS will not need to be aware of detailed configuration changes, something that will be done by the SDN Controller. This approach of delegating the dynamic network control aspects to the SDN controller also minimizes the impact on the existing OSS.

Few service providers or enterprises will have the luxury of a greenfield deployment, therefore many operators will initially consider deployment of SDN in islands. Migration steps, and early deployments, could be SDN based on OpenFlow for intra-datacenter connectivity to support enterprise, carrier IT or NFV services (telco cloud). The WAN interconnect between datacenters could initially rely on existing IP/MPLS installations, which can leverage current protocols (e.g. BGP) to transport service chains or virtual tenant networks between datacenters. WAN programmability and control can be enhanced for consistency with the SDN datacenter by implementing Path Computational Element (PCE) for abstraction of end-to-end path computation and Segment Routing for efficient traffic engineering.

10 Conclusion

SDN and NFV offer numerous advantages to operators from cost savings to increased innovation and new revenue opportunities. To realize these benefits, significant shifts in the OSS/BSS architecture are necessary. This entails the introduction of a new controller or orchestration layer that is able to handle the more agile aspects of the new virtualized and programmable infrastructure.

The contrasting attributes of the legacy and virtualized infrastructure should be considered from an overall management perspective. This will be particularly important during the migration phase while both types of infrastructure are running in parallel. The OSS would, therefore, need to be adapted for near-real time operation, and be able to support a hybrid network across SDN/NFV and non-SDN, non-NFV domains.

Since the granular and dynamic real-time operation of the virtualized network elements will be under the control of the SDN controllers, and not on the OSS itself, this should require minimal changes to the existing OSS. Most of the change required should be absorbed into the new SDN controllers. In this way, a pragmatic evolution path could be provided for brownfield operators that would allow them to cap their investment in legacy transport/network OSS and gradually evolve to common SDN controller and network orchestration platforms across their network/IT operations.

11 Contributors

Frank Ruhl

Shahar Steiff

Shweta Latawa

Patrick Moore

John Hawkins

Theresa Cauble

Gerry Feeney

12 References

http://www.etsi.org/

www.tmforum.org/

13 Abbreviations & Definitions

BSS	Business Support System
FCAPS	Fault, Configuration, Accounting, Performance, Security
NBI	North Bound Interface
NFV	Network Functions Virtualization
OSS	Operations Support System
SDN	Software Defined Network
SLA	Service Level Agreement
MANO	Network Functions Virtualisation Management and Orchestration
NFVI	NFV Infrastructure
NFVO	Network Functions Virtualisation Orchestrator
VIM	Virtualised Infrastructure Manager
VNF	Virtualised Network Function
VNFM	Virtualised Network Function Manager

EMS	Element Management System
NMS	Network Management System